

# Better Buildings / Smarter Cities

Reducing Energy and Costs with Integrated Building Performance Analysis

**CIBSE BSG: Urban Simulation Seminar**  
**14/12/2015**

MASTERPLANNING



DESIGN



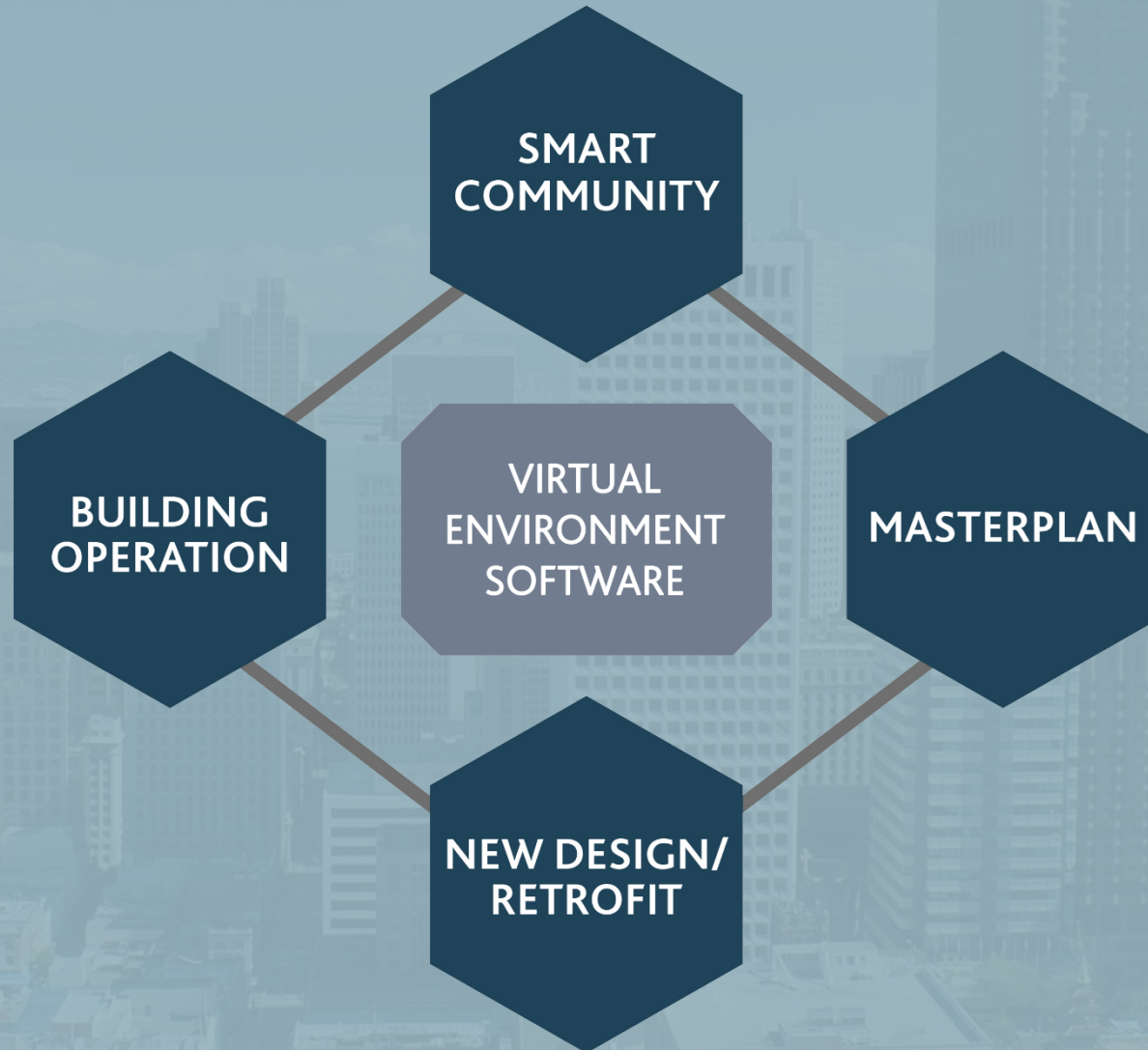
OPERATION



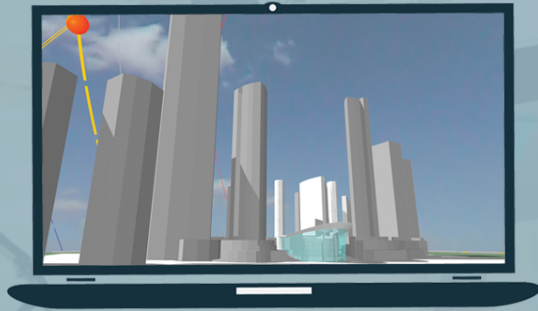
CITY LEVEL



# Better Buildings, Smarter Cities



# An Integrated Approach



## IESVE SOFTWARE

Integrated solutions at all stages  
of design and beyond

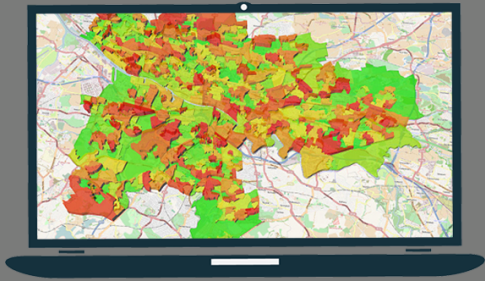
DESIGN

COMMISSIONING

OPERATION



# Research & Development



## IES R&D

We invest over a 1/4 of our revenue on Research and Development projects

MASTERPLANNING



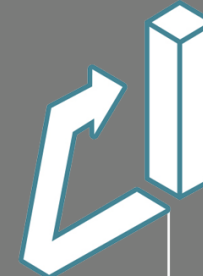
DESIGN



RETROFIT



REAL-TIME CONTROL



SMART CITIES



# Urban Simulation

- ‘Urban simulation’ is becoming mainstream
- Our goal is to ‘integrate’ urban simulation as much as possible with building models
- Sustainable sites and rating systems have touched on this already..



# Location and Transport credits

- LT: Surrounding Density and Diverse Uses
  - Uses our new OpenStreetMap map technology to determine Urban Density (Floor Area ratio calculation) and nearby facilities
- LT: Access to Quality Transit
- LT: Reduced Parking Footprint
- LT: Green Vehicles

# Sustainable Sites credits

- SS: Open Space
- SS: Rainwater Management
- SS: Heat Island Reduction

VE - SunCast - D:\Users\naghman.khan\Desktop\Naghman Khan\VE Models\osm trail\osm trail.mit - Axonometric : Model

File Edit View Tools SunCast Site Image Calculations Options Help

Applications Navigators

**ModelBuilder**  
ModelIT BUILDING MODELLER  
Components COMPONENT MODELLER

**Solar**  
SunCast SOLAR SHADING ANALYSIS

**Energy**  
Apache THERMAL CALCULATION AND SIMULATION  
ApacheHVAC HVAC SYSTEM SIMULATION INTERFACE

Model Images Analysis

Simulation  
Period: Date Range 01/Apr to 30/Sep  
 Use diffuse sky?  
 Hi-resolution grid: 2.5 m Simulate  
Results: Load Save

Display Options  
Display: Energy (kWh/m<sup>2</sup>)  
 Only show values above 1 kWh/m<sup>2</sup>  
Show values on: Building  
False colours: [Color Scale]  
Gradient scale: Relative (min..max)

Display range: 00:00 01/Apr to 23:00 30/Sep  
Apply

Model Viewer II  
Month: Jan Day: 1 Time: 13:06  
Sky Clear I

kWh/m<sup>2</sup>  
711.50  
651.85  
592.21  
532.57  
472.92  
413.28  
353.64  
293.99  
234.35  
174.71  
115.06  
01/Apr - 00:00 to 30/Sep - 23:00

# Urban Simulation Tools

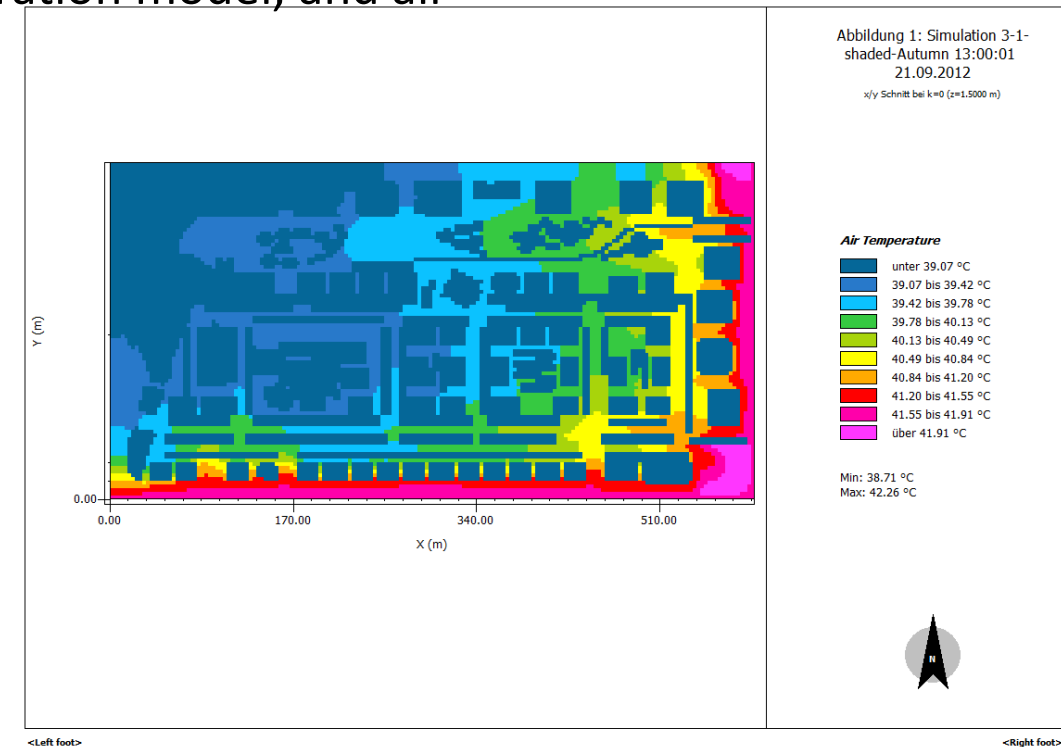
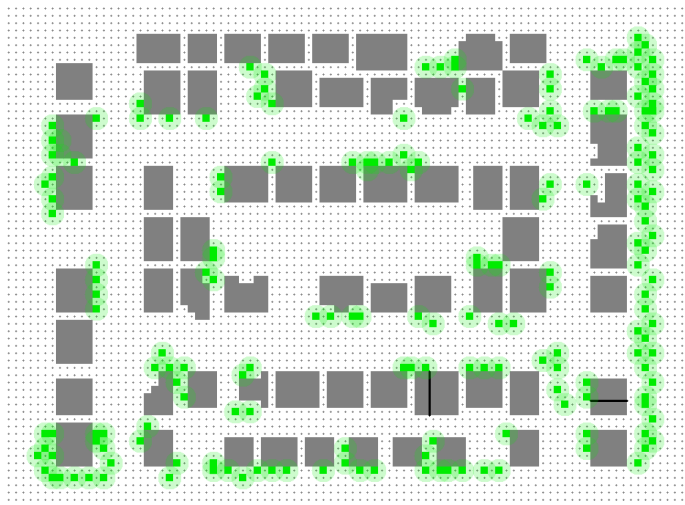
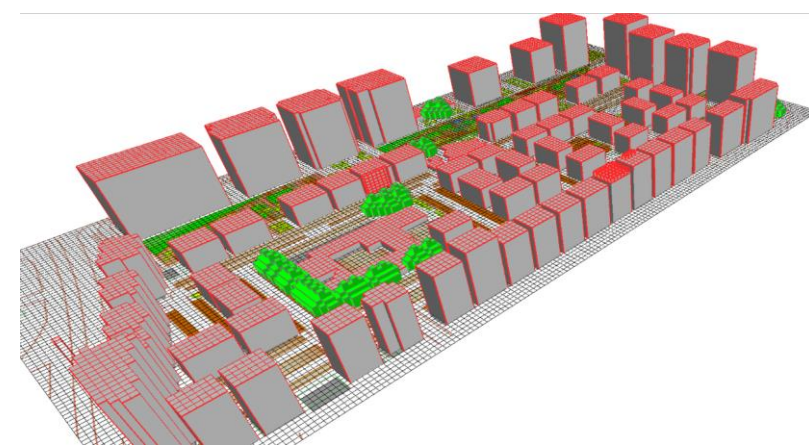
- ENVI-met
- ScStream
- ArchSim & Urban Daylight
- Ladybug+Honeybee
- Urban Modelling Interface
- IES SCAMP



# ENVI-met

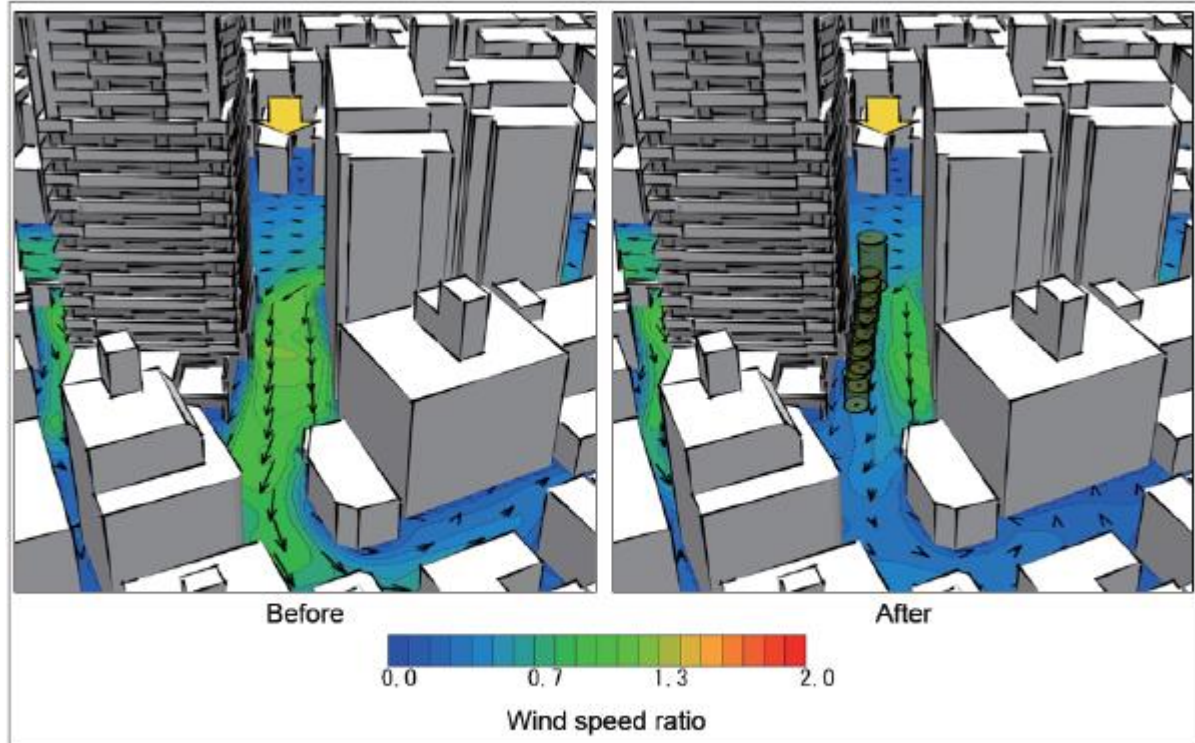
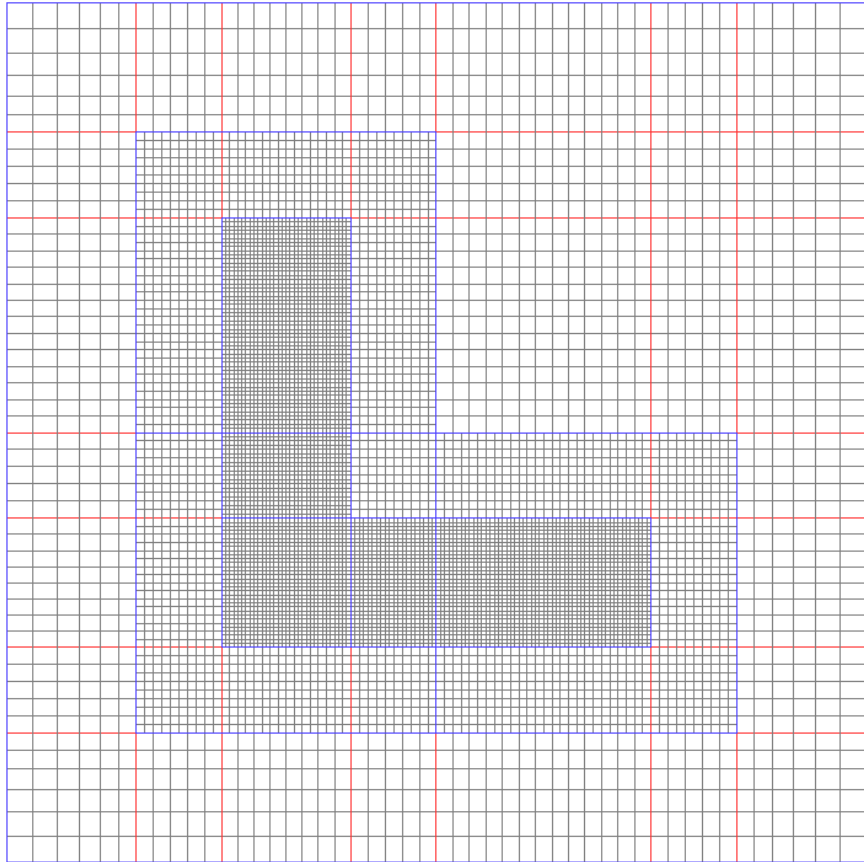


- CFD with limited grid resolution.
- Widely used to explore micro-climate in cities.
- Favourite tool of Urban planners to assess new parks and green areas.
- Solves mass-transfer, heat exchange, radiation, solar gains, humidity and moisture.
- Solves evapotranspiration using a photosynthesis transpiration model, and air pollutants.
- Extended used for the design of parks and green areas.
- Basic capabilities available for free: [www.envi-met.info](http://www.envi-met.info)



# ScStream

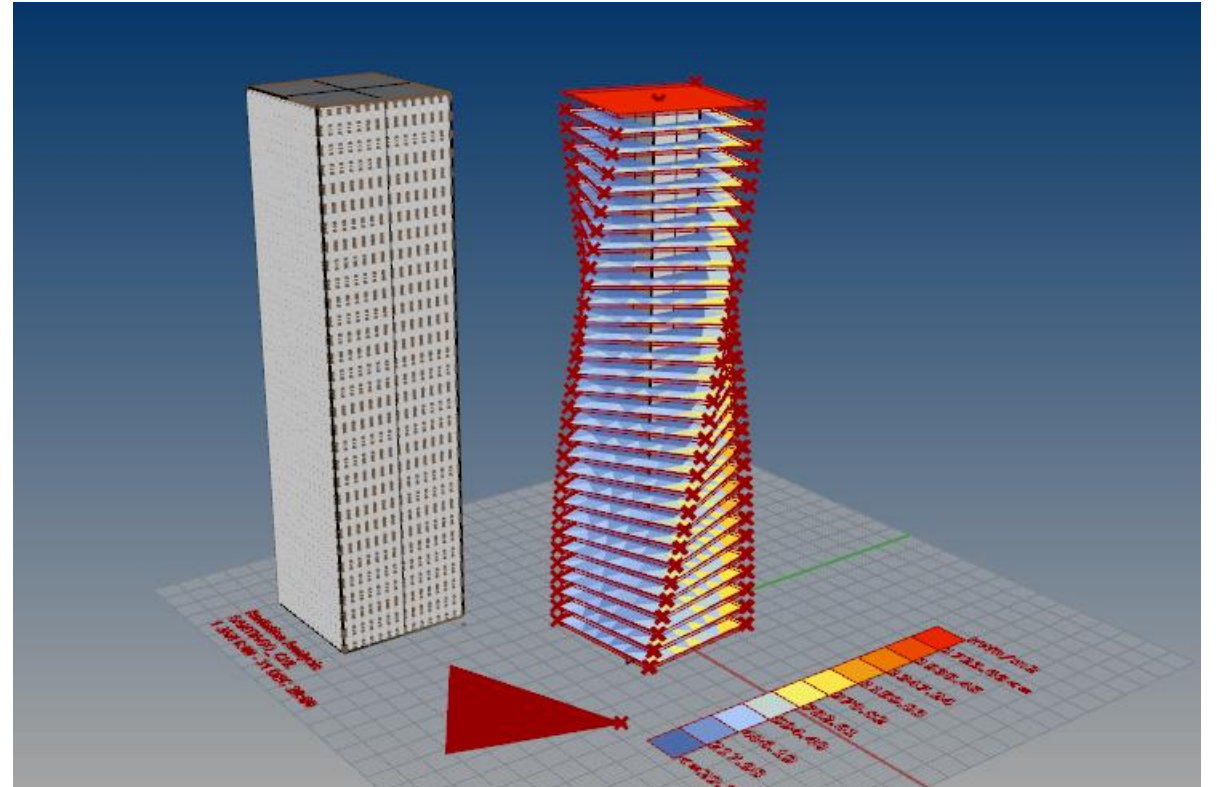
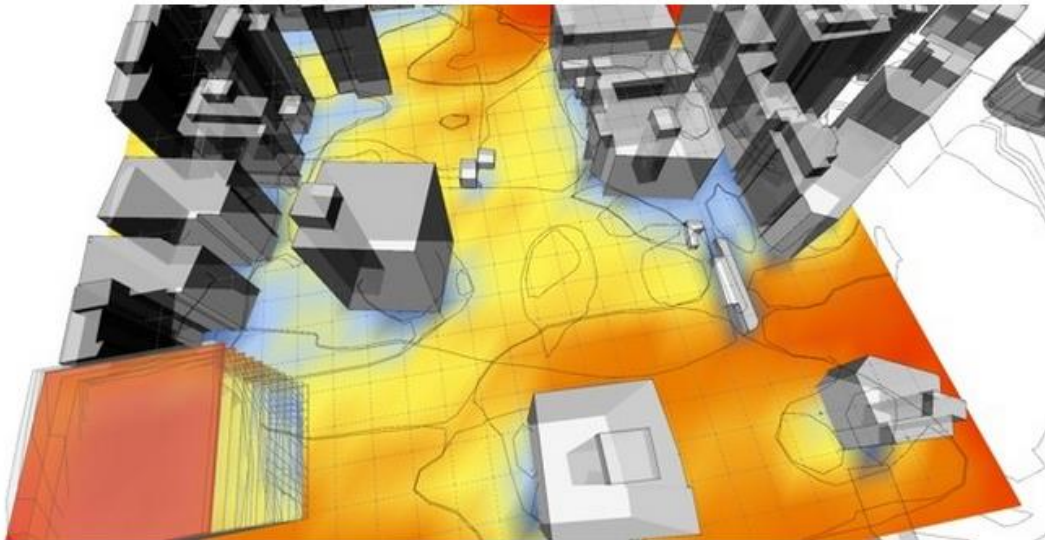
- Widely used to assess the design of HVAC Systems
- Divided into three main programs: Pre-solver, Solver, Post-processing.
- Also solves heat transfer and lumped simulations, Pollutants, Condensation, Moving Objects.



Effect of roadside trees on alleviating strong wind (Tokyo)

# Ladybug+Honeybee

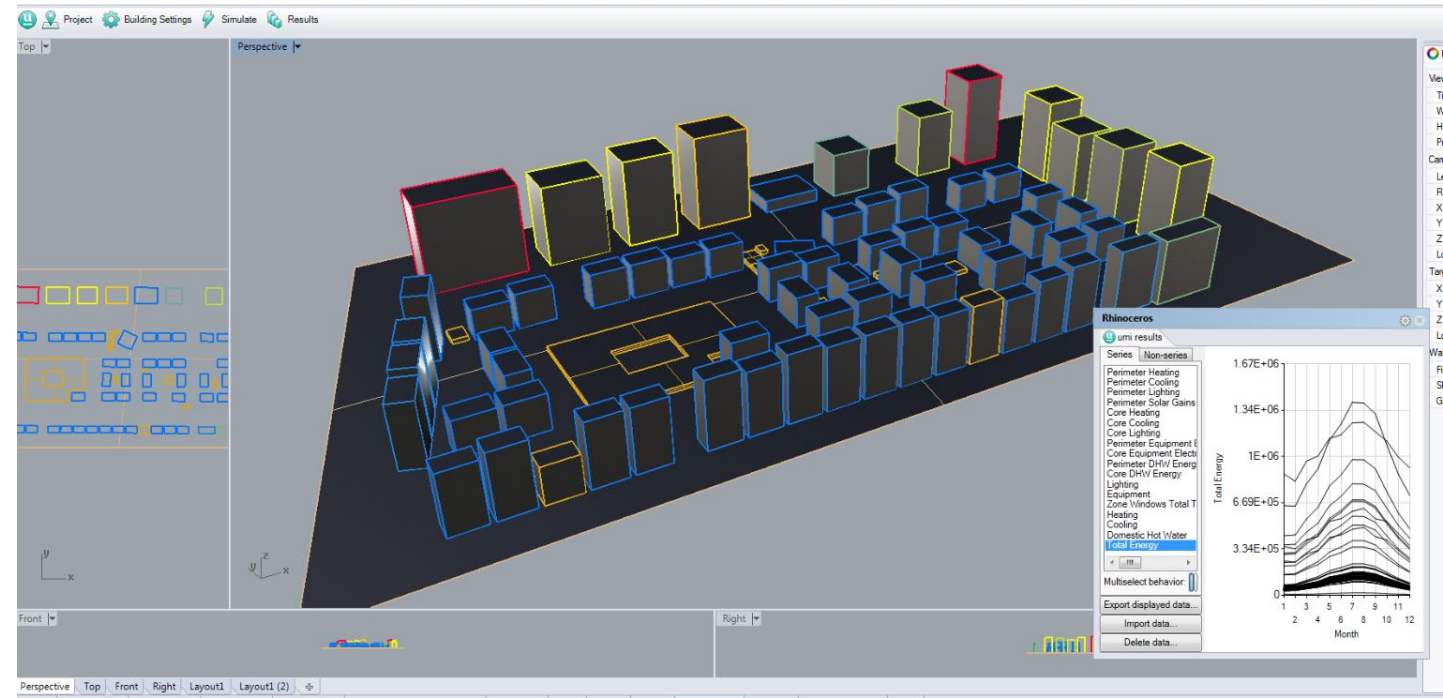
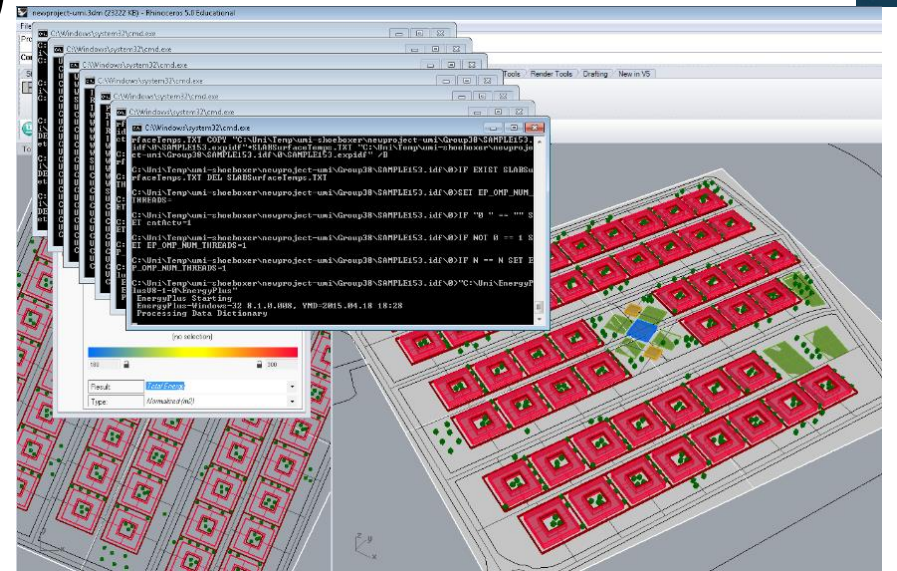
- Environmental analysis included and optimisation tools, some level of scripting and interfacing





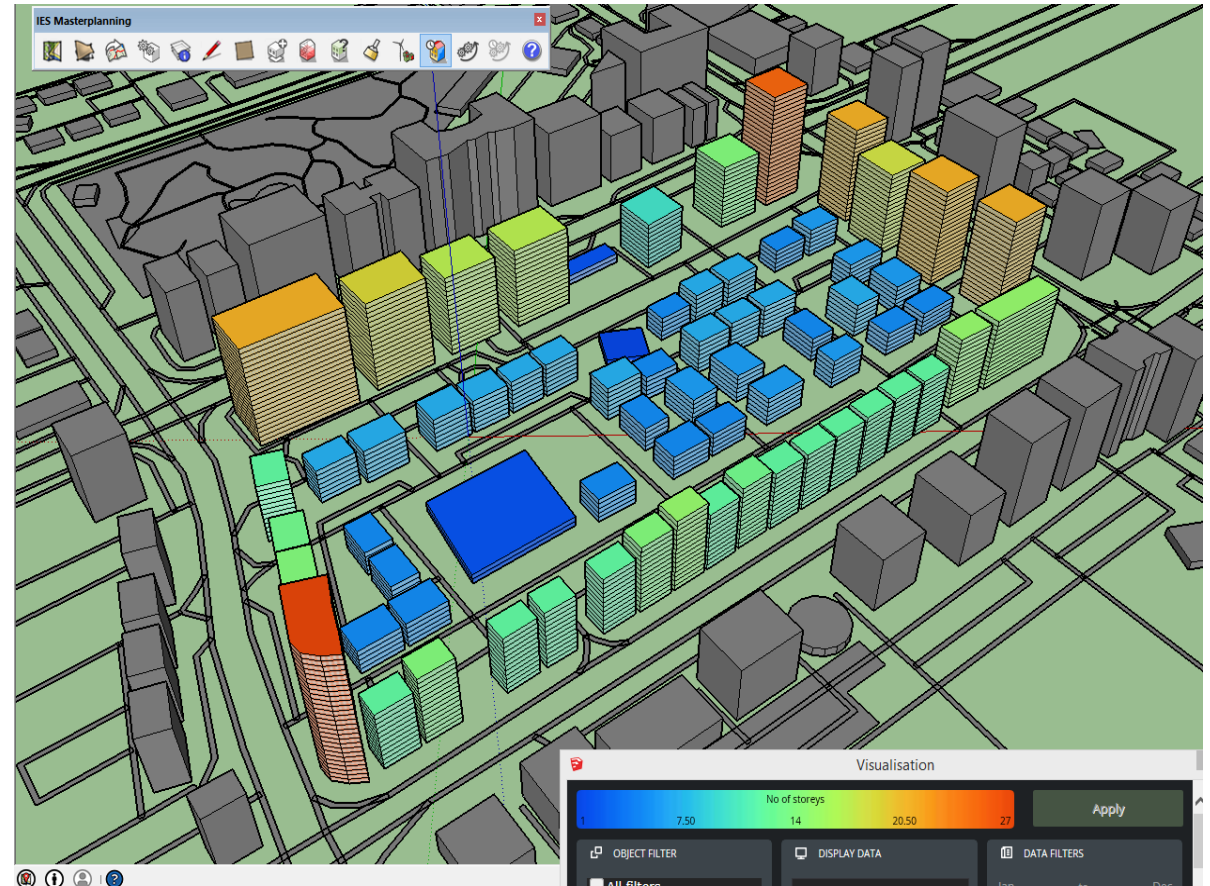
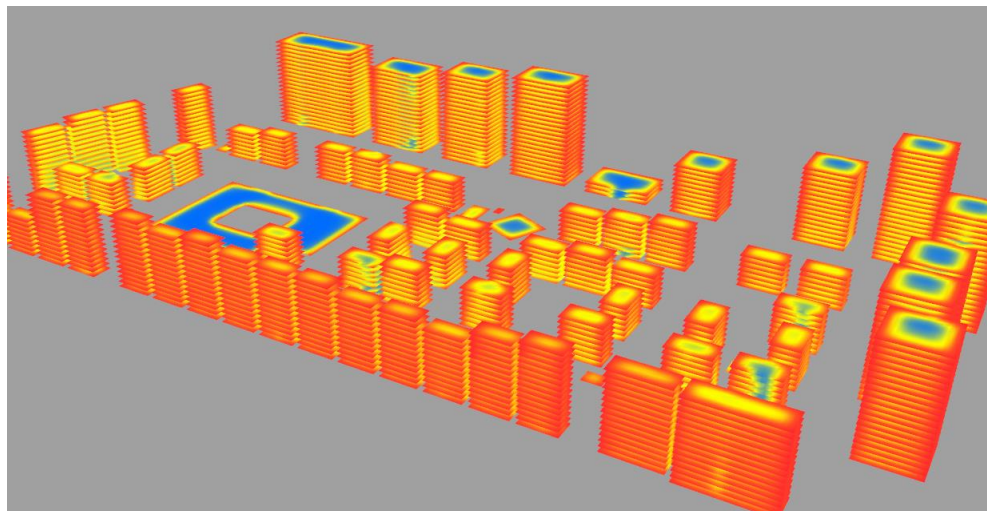
# Urban Modelling Interface (UMI)

- Developed by the Sustainable Design Lab at MIT, 2014.
- Umi is a Rhino-based design environment.
- Tool for architects and urban planners.
- Asses the neighborhood in:
  - operational energy use.
  - embodied energy.
  - Walkability.
  - Daylighting potential.



# IES SCAMP

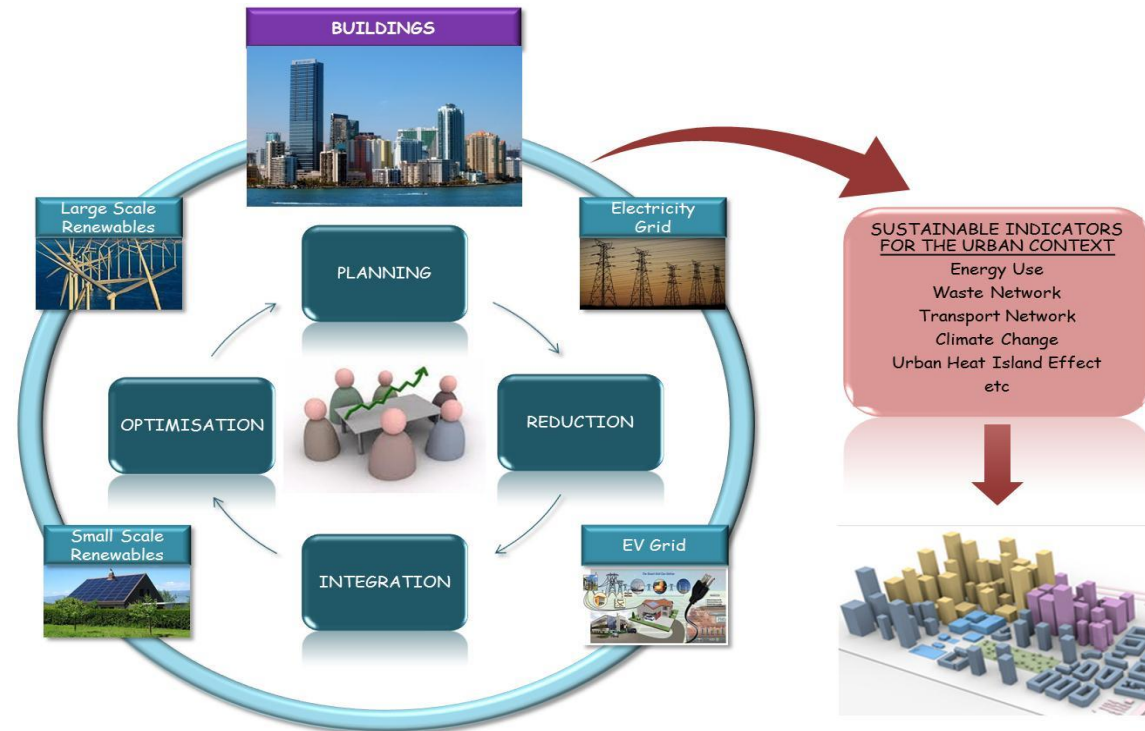
- Currently in development phase.
- Plug-in used in Sketch Up.
- Very friendly tool.
- Uses the VE engine: SunCast and Apache.



# INDICATE

Develop a decision support tool that will provide dynamic assessment of the interactions between buildings, the electricity grid, and Renewable Technologies and Information Communication Technologies...

## Four Key Strands....





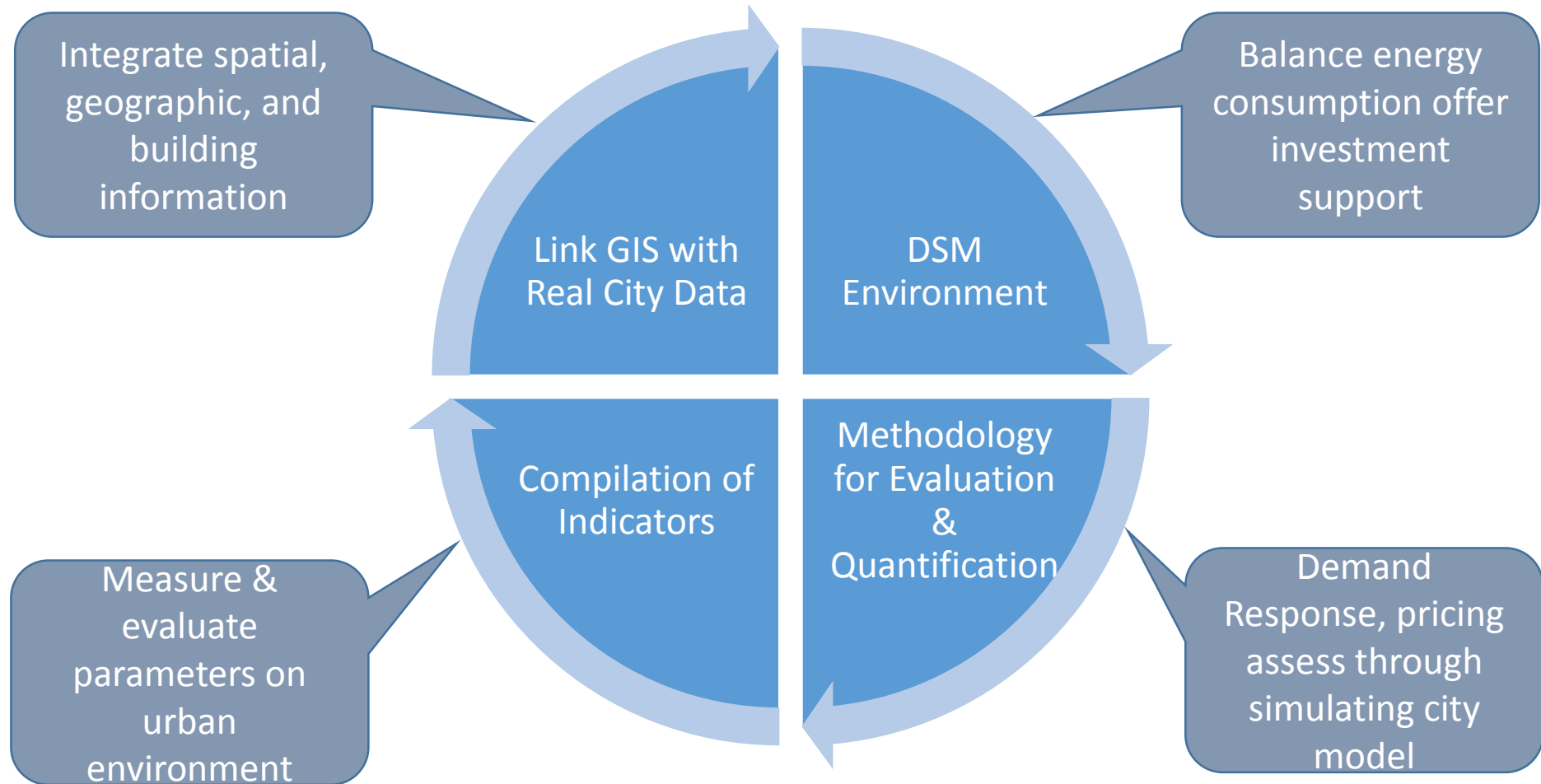
# Concept



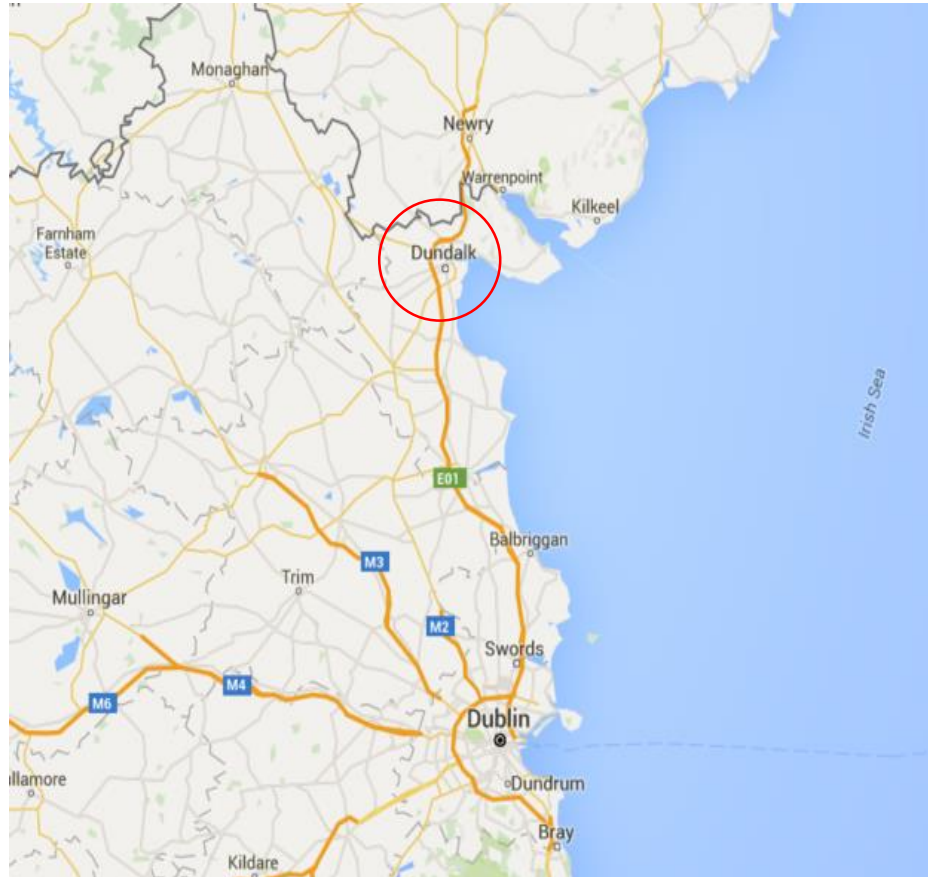
**PLAN:** development through a dynamic simulation, energy-based decision support tool, which takes into account the buildings and their interaction with the urban environment

**INTEGRATE:** new technologies and services in a city to better manage supply and demand, via DSM, GIS & 3D urban modelling that will reliably inform the impact of the integrated technologies

# Main Outcomes



# Test Sites



Dundalk, Ireland



Genoa, Italy

# Dundalk

- Act as a pilot city
- Will be used to assess the low-level masterplanning aspect of the INDICATE tool
- High-level optimisation strategies





# Low Level Master-planning

## Dundalk Urban Model

- Missing height data, building modelled with default height of 2.5m per floor
- Height data applied and divided equally on identified building with more than one floor.
- Unavailable data on glazing size, most buildings were modelled with assumption of between 15-30% of external façade
- Dundalk Urban Model to be refined further –update information on glazing size and no. of floors



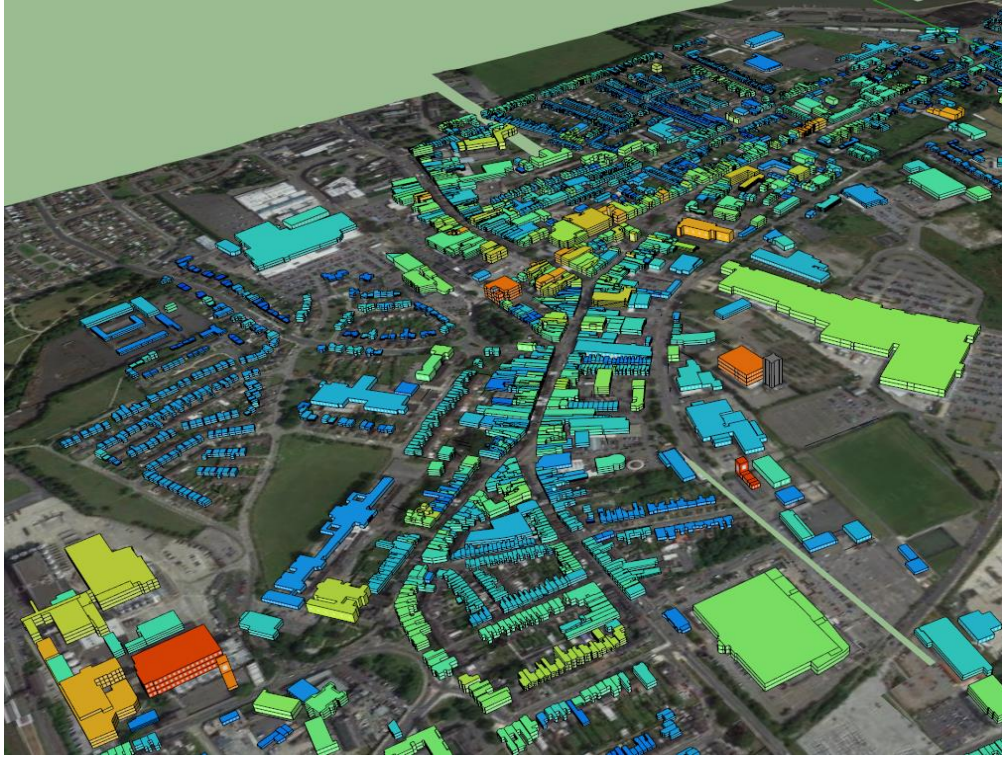


# Building Typologies modelled

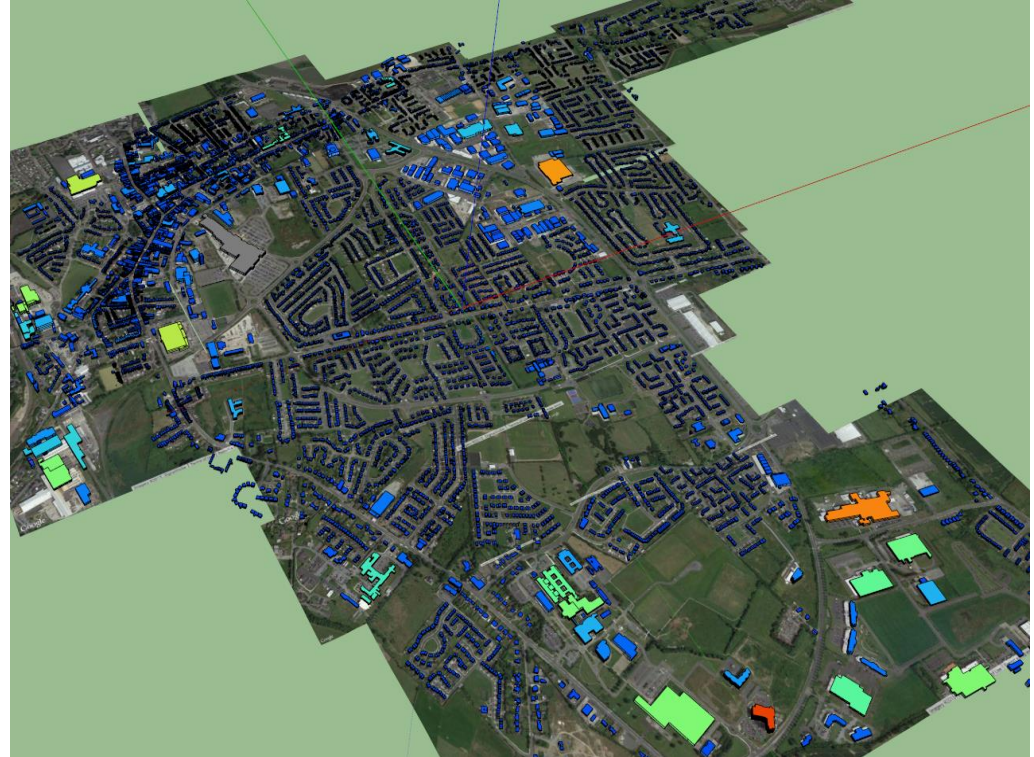


Building type	Courthouse	Dining or Bar or Lounge at	Dining or Cafeteria or	Dormitory	Exercise Center	Fire Station	Gymnasium	Hospital or Healthcare	Hotel	Library	Manufacturing	Multiple Family	Museum	Office	Performing Arts Theater	Police Station	Post Office	Place of Worship	Retail	School or University	Single Family Dwelling	Sports Arena	Town Hall	Transportation Warehouse	Workshop
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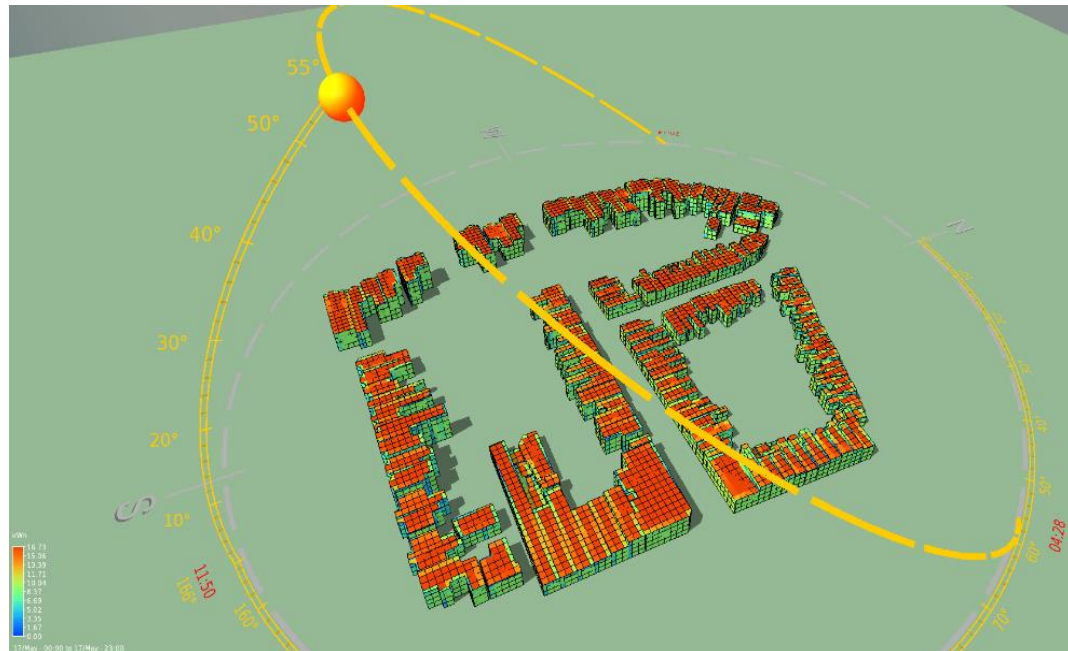
Height of Building in Dundalk Town



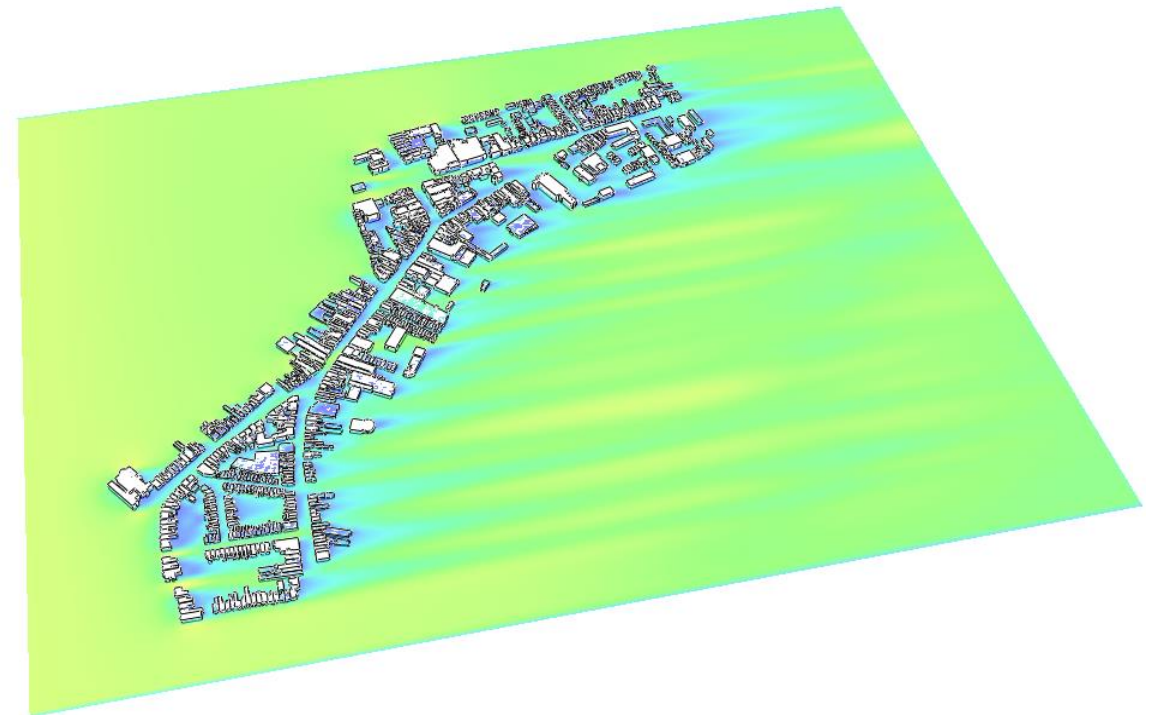
Building Floor area in Dundalk Area



- Modelled Buildings in Vincent Avenue, Dundalk Town imported into IES <VE> software
- Solar Radiation on the external surface of the buildings in Dundalk
- Solar Radiation Metrics Calculation
  - Solar Incident Annual (kWh/m<sup>2</sup>/yr)
  - Number of hours surface receive solar radiation
- Analysis potential of Solar PV on Dundalk building rooftop and external facades
- Historical Weather File use in simulation



- **Model of Dundalk Town imported into IES <VE> software**
- **Wind Speed range of 2 – 5m/s surrounding the buildings in Dundalk Town**
- **Dense Colouring (Blue) = higher wind speed**





# Energy Analysis

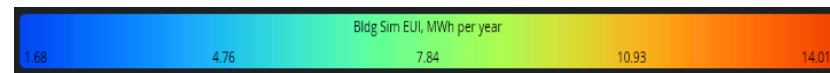
- Cluster of Residential Buildings in Muirhevena-Mor District
- Detailed Input parameter modelled
  - Construction
  - Internal Gain
  - HVAC
- Energy Simulation Calculation
- Different Simulated energy result metrics

*Average EUI retrofit construction simulated – 28.50 kWh/m<sup>2</sup>/year against baseline of 45.79 kWh/m<sup>2</sup>/year*

Refurbishment Scenario	Average EUI (kWh//m <sup>2</sup> /yr)
Baseline	45.79
External Wall, Ground Floor and Ceiling retrofit	28.50
Window Retrofit	43.19

▼ Thermal

Fossil fuel	Natural gas
Ceiling	100mm Reinforced-C
Roof	6 In. Heavy Weight C
Ground floor	Un-Insulated Solid-Gr
Door	Wooden Door
Ext wall	Wall 12 In. Concrete
Int wall	13mm L/W Plaster 10
Ext window	Low-E Double Glazini
Int window	Low-E Double Glazini
Roof light	Polycarbonate Double

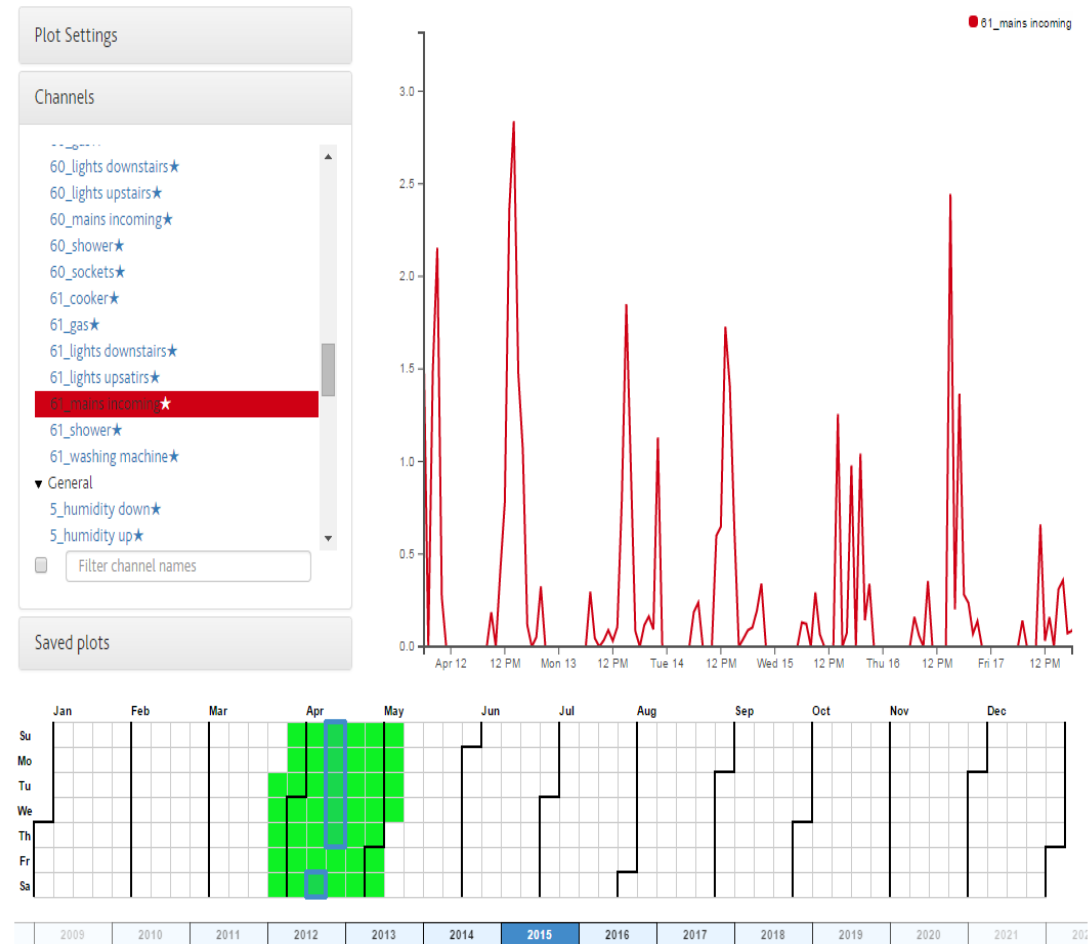


# Energy Analysis



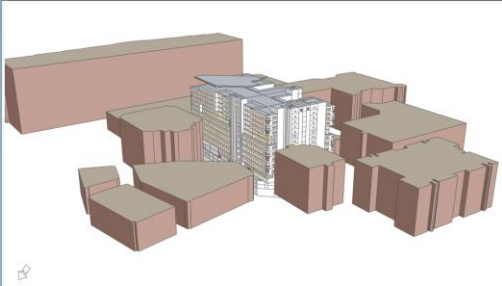
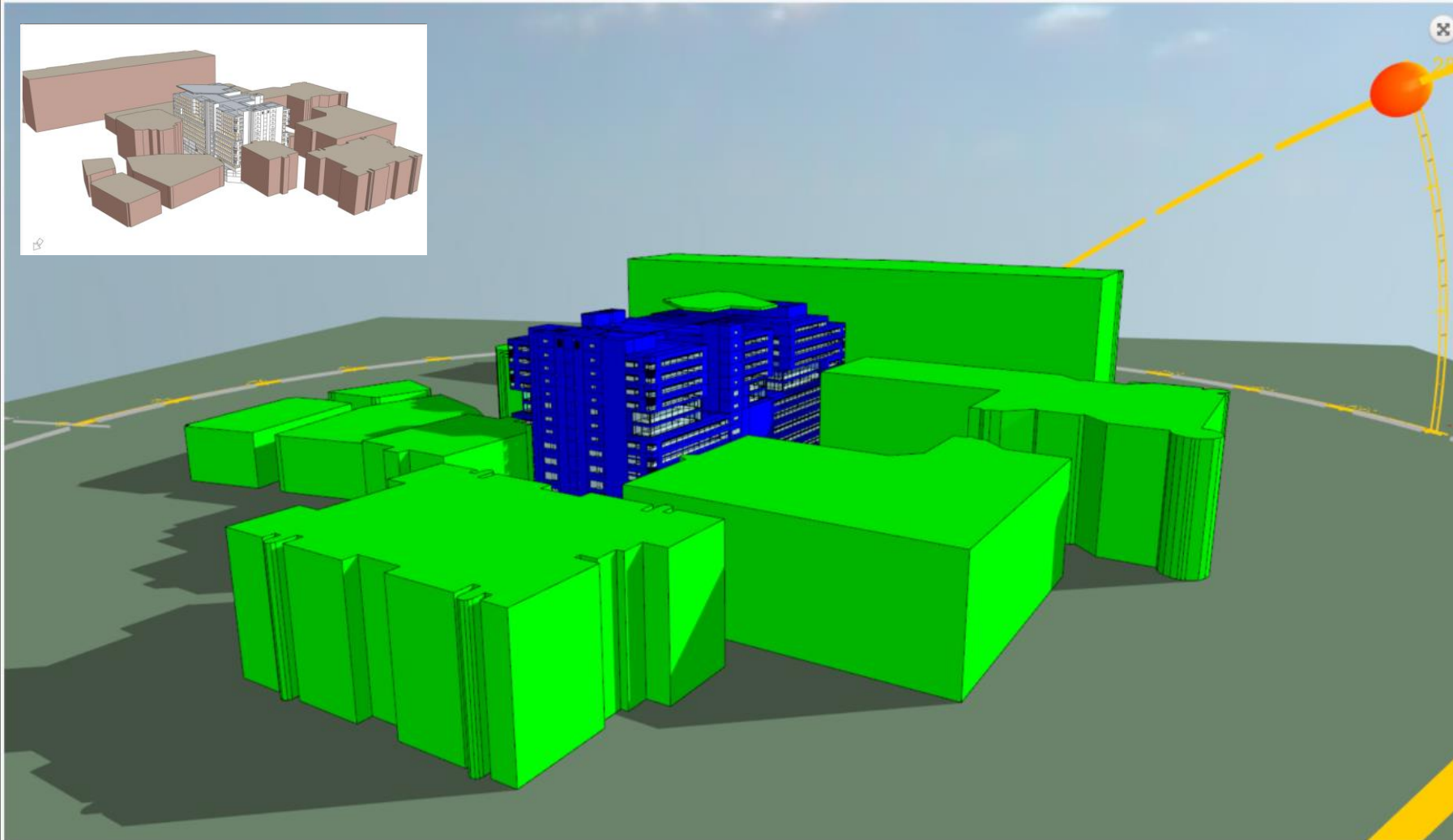
- IES have selected and received continuously metered Data from building sites in Dundalk and uploaded into IES-SCAN technology software

Data Plot - MuirhevnaMor - 2015-04-11 to 2015-04-17





# Integrated Data Sets



## CITY INFORMATION MODEL

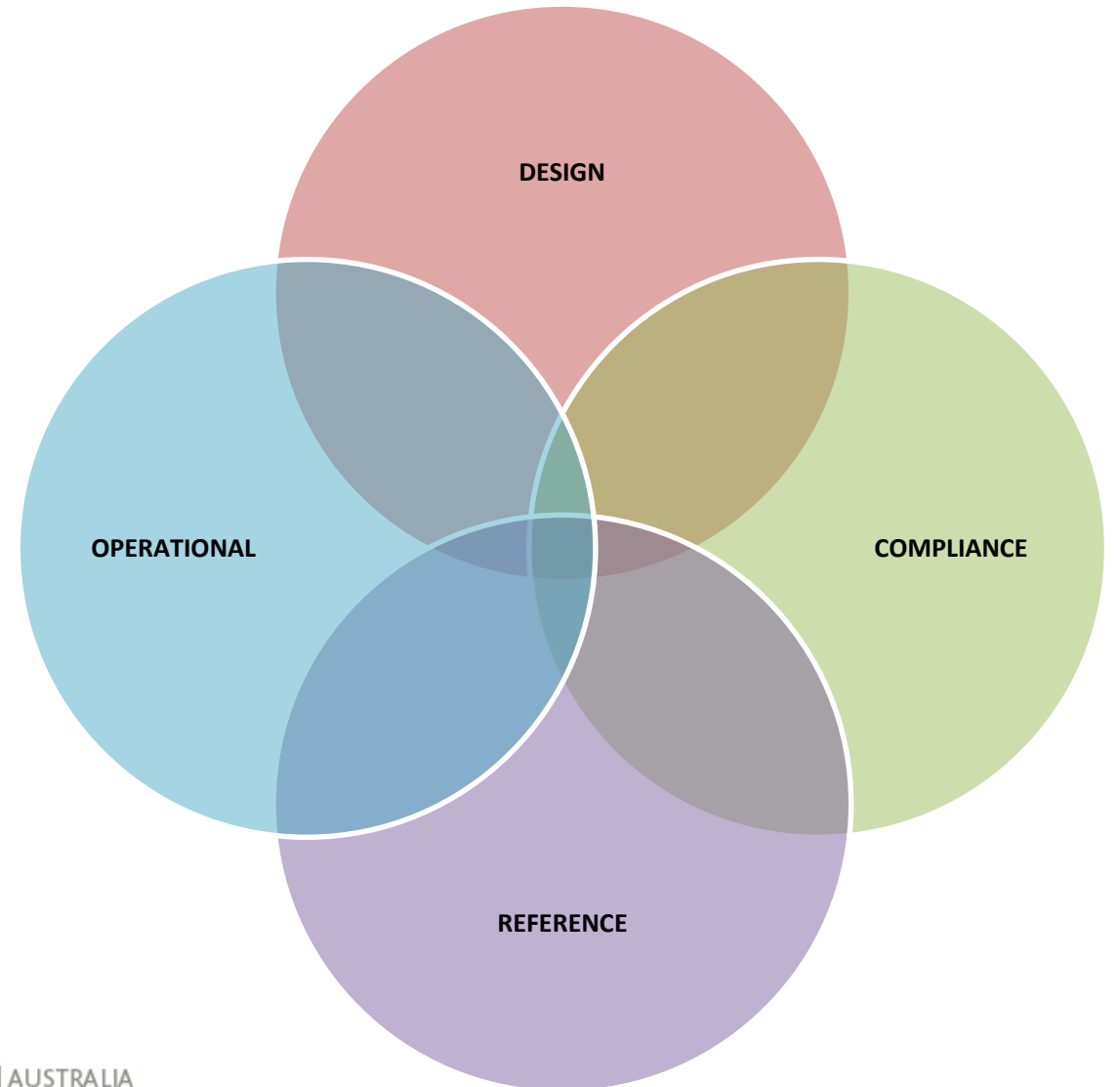
- Master-planning
- Urban Planning
- Urban climatology
- Air quality data
- Traffic
- Energy flows
- Transport
- Surface Temps
- Scenario testing
- Adaptation
- Water flows / hydrology



# FINAL THOUGHTS



Building Energy Simulation Tools are used to analyse buildings for a range of purposes. Some of these purposes require a specific type of model that is specific to its purpose.



What does an urban simulation model look like?

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